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Japanese Kokai Patent Application No. Hei 5[1993]-291650

Translated from Japanese by the Ralph McElroy Co., Custom Division
P.O. Box 4828, Austin, Texas 78765 USA

Code: 1919-59532
Ref. No.: Watson T

JAPANESE PATENT OFFICE

PATENT JOURNAL

KOKAI PATENT APPLICATION NO. HEI 5[1993]-291650

Technical Disclosure Section

Int Cl.^{5}:	H 01 S 3/036 3/00 3/134 H 01 S 3/03
Sequence Nos. for Office Use:	8934-4M 7454-4M 7454-4M
Application No.:	Hei 4[1992]-94546
Application Date:	April 14, 1992
Publication Date:	November 5, 1993
No. of Claims:	13 (Total of 9 pages)
Examination Request:	Requested

GAS DETERIORATION DETECTION DEVICE AND EXCIMER LASER EQUIPPED WITH SAID DEVICE

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[There are no amendments to this patent.]

Abstract

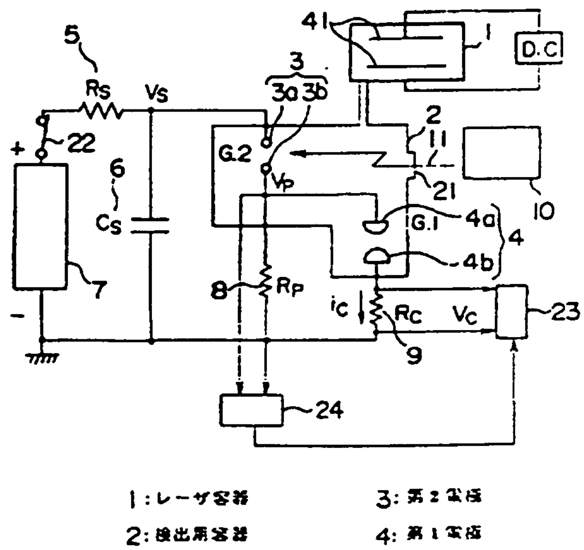
Purpose

To offer a compact gas degradation detection device that can detect the concentration of halogen gas in an excimer laser chamber in a short period of time, and an excimer laser device with said detection device.

Constitution

The present invention comprises a detection chamber that communicates with a laser chamber filled with a halogen-containing gas; a pair of first electrodes that are arranged within the aforementioned chamber; a voltage pulse

generating means that applies a voltage pulse to the aforementioned first electrodes and a measuring means that measures the voltage across the aforementioned first electrodes and the current flowing between them.



Application example of the present invention (Figure 1)

Key:
1 Laser chamber
2 Detecting chamber
3 Second electrodes
4 First electrodes

Claims

1. A gas deterioration detection device characterized by the fact that it is equipped with a detection chamber that communicates with a laser chamber filled with a halogen-containing gas; a pair of first electrodes that are arranged within the aforementioned chamber; a voltage pulse generating

device which applies a voltage pulse to the aforementioned first electrodes and a measuring means that measures the voltage across the aforementioned first electrodes and the current flowing there between.

2. The gas deterioration detection device of Claim 1, characterized by the fact that the aforementioned voltage pulse generating means is equipped with a pair of second electrodes that are arranged within the aforementioned detection chamber a power source that applies a voltage across the aforementioned second electrodes and a light source that irradiates light between the aforementioned second electrodes.

3: The gas deterioration detection device of Claim 2, characterized by the fact that it is equipped with a light source that irradiates electromagnetic radiation between the aforementioned first electrodes.

4. The gas deterioration detection device of Claim 2 or 3, characterized by the fact that the aforementioned electromagnetic radiation is in the form of ultraviolet light or an electron beam.

5. The gas deterioration detection device of Claim 1, characterized by the fact that the aforementioned measuring means performing measurements synchronously with the aforementioned generation of the voltage pulse.

6. The gas deterioration detection device of Claim 4, characterized by the fact that the aforementioned light source is a laser light source.

7. An excimer laser equipped with a laser chamber which is filled with a halogen-containing gas; a pumping means that excites the aforementioned halogen-containing gas and an output window through which the laser light that oscillates in the laser

chamber exits, characterized by the fact that it is equipped with gas deterioration detection first electrodes which are arranged within the aforementioned laser chamber; a voltage pulse generating means which applies a voltage pulse to the aforementioned electrodes and a measuring means that measures the voltage across the aforementioned electrodes and the current flowing therebetween.

8. The excimer laser of Claim 7 with the aforementioned gas deterioration detection means, characterized by the fact that the aforementioned voltage pulse generating means is equipped with a pair of second electrodes which are arranged within the aforementioned laser chamber; a power source which applies a voltage across the aforementioned second electrodes and a light source that irradiates light between the aforementioned second electrodes.

9. The excimer laser device in Claim 7 with the aforementioned gas deterioration detection means, characterized by a gas flow rate adjustment means that adjusts the quantity of the halogen-containing gas introduced into the aforementioned laser chamber; a calculation means that calculates the impedance of the aforementioned first electrodes from the current and voltage measured by the aforementioned measuring means, and a control means that obtains the necessary quantity of gas to be introduced from the aforementioned calculated results using the relationship between the previously obtained halogen concentration and the impedance and controls the aforementioned gas flow rate adjustment means.

10. The excimer laser of Claim 9 with the aforementioned gas deterioration detection means, characterized by the fact that the aforementioned control means obtains the change in the

aforementioned impedance with time and controls the aforementioned gas flow rate adjustment means so that the change in the aforementioned impedance with time will fall below a preset prescribed value.

11. The excimer laser of Claim 9 or 10, with the aforementioned gas deterioration detection means, characterized by the fact that it is equipped with a laser light intensity detection means that measures the intensity of the laser light emitted through the aforementioned output window and a display means, wherein the aforementioned control means controls the aforementioned display means to indicate when the intensity of the aforementioned laser light falls below a preset prescribed value.

12. The excimer laser of Claim 11 with the aforementioned gas deterioration detection means, characterized by the fact that the aforementioned display indicates when an abnormality occurs at the aforementioned output window.

13. A halogen gas concentration detection device, characterized by the fact that it comprises a pair of electrodes that are arranged in the within a halogen-containing gas, and a measuring means that measures the impedance between the aforementioned electrodes, wherein the concentration of halogen gas is attached from the aforementioned impedance by using a pre-established relationship between halogen gas concentration and impedance.

Detailed explanation of the invention

[0001]

Industrial application field

The present invention concerns a high-pressure laser. In particular, it concerns an excimer laser that uses a noble gas and a gas that contains a halogen as the lasing medium.

[0002]

Prior art

In an excimer laser, the laser container is filled with a noble gas and halogen at relatively high pressure, said gas is excited, and the laser oscillates. The means generally used to excite the gas is an applied voltage or an electron beam source.

[0003]

The output of an excimer laser that uses a halogen gas gradually decreases with operating time. Major causes for the decrease are dirtying of the output window of the laser light and the consumption and consequent in decrease of the halogen-containing gas as the lasing medium. The consumption and decrease of the halogen gas are caused when the halogen-containing gas, such as active HCl and F_2, for example, react with materials that make up the laser, such as the discharge excitation electrodes and the laser chamber, for example.

[0004]

Therefore, as a measure of the said decrease in the laser output that accompanies the consumption in the concentration of the gas, a device that controls the power supply that applies a voltage to the excitation electrodes and the amount of halogen gas introduced, has been published by J. Reid et al.: Metal Vapor, Deep Blue, and Ultraviolet Lasers, SPIE O-E/LASE'89, p. 186(1989).

[0005]

Also, a method to detect a decrease in the halogen concentration of the laser gas includes the known method in which part of the gas in the laser chamber is extracted and analyzed through ion chromatography.

[0006]

Problems to be solved by the present invention

In the aforementioned conventional technology, the decrease in laser output can be considered a decrease in the halogen concentration, so that the supply of halogen gas is controlled. However, a decrease in the halogen concentration is not the only cause of decreased laser output, and in some cases, therefore, a decrease in the laser output is not directly attributable to a change in the halogen concentration. If the decrease in the laser output is considered to be due to a decrease in the halogen concentration in these cases, and the gas continues to be

introduced until the laser output recovers, excess halogen concentration occurs. The excess supply makes the discharge unstable, and there is also the problem in which the control system will be unstable as well.

[0007]

When the detection of the concentration of the halogen gas is performed through ion chromatography, which is another conventional technique, there is the advantage of accurate detection, but there is the problem that it takes time to extract the gas and measure the gas concentration; as a result, the flow rate of the halogen-containing gas cannot be controlled while the laser is in operation. Also, there is the problem that ion chromatographs are large and expensive.

[0008]

The aim of the present invention is to offer a compact detection device, in which the conventional problems are solved and which detects the the halogen concentration in the excimer laser chamber in a short period of time, and an excimer laser with said detection device.

[0009]

Means to solve the problems

The first invention for realizing the aforementioned aim offers a gas deterioration detection device, characterized by the

fact that it is equipped with a detection chamber that communicates with a laser chamber filled with a halogen-containing gas; a pair of first electrodes that are arranged within the aforementioned chamber; a voltage pulse generating device which applies a voltage pulse to the aforementioned first electrodes and a measuring means that measures the voltage across the aforementioned first electrodes and the current flowing therebetween.

[0010]

The second invention is an excimer laser that is equipped with a laser chamber that is filled with the halogen-containing gas, a pumping means that excites the aforementioned halogen-containing gas, and an output window through which the laser light that oscillates in the laser chamber exits, wherein the excimer laser is equipped with the gas deterioration detection means, which is characterized by the fact that it is equipped with gas deterioration detection first electrodes which are arranged within the aforementioned laser chamber; a voltage pulse generating means which applies a voltage pulse to the aforementioned electrodes, and a measuring means that measures the voltage across the aforementioned electrodes and the current flowing therebetween.

[0011]

Function

When electrons are supplied to the halogen-containing gas, electrons adhere to the halogen, and halogen ions are created. It can be viewed that these halogen ions correspond to the concentration of halogens that are included in the gas. Accordingly, the concentration of halogens can be measured if the concentration of these halogen ions can be measured.

[0012]

The inventors of the present invention thought that the concentration of halogen ions could be measured by arranging a pair of electrodes within a gas in a detection device which communicates with the laser chamber, supplying electrons through the application of a D.C. voltage between these electrodes, and measuring the current that flows between these electrodes. However, said halogen ions become extinct in a short period of time on the order of several μsec, therefore, it is extremely difficult to capture and measure the current which is created between these electrodes.

[0013]

Therefore, measurements became possible in the present invention by applying a voltage pulse between a pair of first electrodes from a voltage pulse generating means and applying a drastic change in voltage, and by measuring the current and

voltage between the first electrodes synchronously with this applied voltage.

[0014]

More precisely, in the present invention, electrons are accelerated by the voltage pulse between the pair of first electrodes, they adhere to halogens and change the halogens into anions. The measuring means measures the micro-current that flows between the electrodes instantly at the application of the voltage synchronously with the applied voltage. This micro-current is low when the concentration of halogens is high, and, conversely, the current is high when the concentration is low. Accordingly, the space between the electrodes can be characterized as a type of impedance from the micro-current that flows between the electrodes and the voltage. The halogen concentration can be determined from the impedance by knowing the relationship between the halogen concentration and the impedance.

[0015]

A voltage pulse application means can be used. A voltage is applied to a pair of second electrodes which are arranged within the aforementioned detection chamber. An arc discharge is further created through the irradiation of light between the electrodes, and a voltage pulse is generated. The discharge voltage between the electrodes differs according to the halogen concentration gas included in the gas at the aforementioned first electrodes. In addition to the interaction of the application of the voltage pulse, there is the interaction that preliminarily ionizes the

space between the first electrodes through an arc discharge of the second electrodes, therefore, a micro-current easily flows between the first electrodes.

[0016]

Also, halogen atoms have a large electron affinity; therefore, there is a strong tendency for the electrons to adhere to halogens and become ions, and the ionization interaction can be easily prevented. Accordingly, the electron density changes by the makeup of the laser halogen-containing gas. By utilizing this, it is also possible to detect the condition of the gas by using the electron density that can be converted by the current that flows between the first electrodes.

[0017]

Application example

A gas deterioration detection device in an application example of the present invention will be explained with reference to the figures below. As shown in Figure 1, the gas deterioration detection device in this application example has a detection chamber (2), which is attached to one end of a laser chamber (1). A pair of first electrodes (41) are arranged inside the laser chamber (1), which is filled with Xe gas, HCl gas, or Ne gas as the lasing medium. The detection chamber (2) and the laser chamber (1) communicate, and the gas within the laser chamber (1) also fills the inside of the detection chamber (2).

[0018]

Also, a pair of second electrodes made of Ni G2 (3a) and (3b) and a pair of first electrodes made of Ni G1 (4a) and (4b) are insulated from the detection chamber (2) and are arranged within the detection chamber (2). The first electrodes G1 (4a) and (4b) and the second electrodes G2 (3a) and (3b) are arranged in close proximity. Also, an ultraviolet light input window (21) is attached to one section of the detection chamber (2). An ultraviolet light emission lamp (10), which is arranged at the outside of the detection chamber (2), irradiates ultraviolet light (11) between the second electrodes G2 (3a) and (3b) through the ultraviolet light input window (21). In this application example, a mercury lamp was used as the ultraviolet light emission lamp (10).

[0019]

A high-value resistor (Rp) (8) in the range of several megohms is connected between the second electrode (3b) and ground. Also, a capacitor (6) with a capacitance Cs is connected in parallel with the second electrodes (3a) and (3b) and the high-value resistor (8). A high-value resistor (Rs) (5) in the range of several megohms is connected to the second electrode (3a), and a power supply (7) is connected to the other end of the high-value resistor (5) through a switch (22). The ground side of the said high-value resistor (8) and one end of the capacitor (6) are connected to the power supply (7).

[0020]

Also, the second electrode (3b) is connected to the first electrode (4a), and a resistor (Rc) (9) of 100 Ω is connected to the other end (4b) of the first electrode. The other end of the resistor (9) is connected to the high-value resistor (8) and is also grounded, and a circuit is constructed. More precisely, the first electrodes (4a) and (4b), which are connected (9) in series to the resistor are distributed parallel to the high-value resistor (8). Also, the voltage measuring means (23) is connected to both ends of the high-value resistor (9). The voltage measuring means (24) is connected to both ends of the high-value resistor (8), and the voltage Vp is measured. The voltage measuring means (24) sends a signal that instructs a measurement to the voltage measuring means (23) after detecting the voltage Vp. The voltage measuring means (23) is synchronized with this signal and measures the voltage Vc of the resistor (9).

[0021]

When the switch (22) of the gas deterioration detection device with the structure of this application example is turned on, the capacitor (6) is charged through the high-value resistor (5). At the same time, the voltage Vs across the capacitor (6) is also applied to the second electrodes (3a) and (3b) and to the high-value resistor (8) as shown in Figure 2(a). The distance between second electrodes (3a) and (3b) is preadjusted, so that there is no immediate discharge when the voltage Vs is applied. Here, when the light (11) of the ultraviolet light emission lamp (10) is irradiated between the second electrodes as shown in

Figure 2(b), the gas between the second electrodes (3a) and (3b) is subject to the effects of the trigger and the preliminary ionization depending on the ultraviolet light (11), and in this way, a discharge between the second electrodes (3a) and (3b) begins. The space between the first electrodes (4a) and (4b) is subject to the effects of preliminary ionization through the discharge between the second electrodes (3a) and (3b).

[0022]

The resistance of resistor (8) is large; therefore, almost all the voltage Vs is applied across the high-value resistor (8) when the second electrodes (3) discharge. In other words, a voltage of Vp=Vs is applied across the resistor (8) as shown in Figure 2(c).

[0023]

Because the series circuit of the first electrodes (4) and the resistor (8) is connected in parallel to the high-value resistor (8), the voltage Vp is also simultaneously applied between the first electrodes (4a) and (4b). The gap between the first electrodes is greater than that between the second electrodes, and it is higher than the discharge voltage of the second electrodes. Accordingly, the first electrodes (4) do not have a short-circuit discharge for the applied voltage, but they receive the preliminary ionization interaction from the discharge of the second electrodes (3), and a micro-current (dark current) Ic flows. As shown in Figure 2(d), at the time when voltage Vp is applied across the first electrodes (4) at the resistor (9) to

generate a microcurrent, a voltage of Vc1 is applied to generate micro-current Ic. The current Ic which flows through the resistor (9) times the resistance (9) is the voltage Vc measured by the measuring means (23).

[0024]

If the micro-current Ic continues to flow into the first electrodes (4) in this way, the voltage Vp will be attenuated with the time constant Cs·Rp as indicated by the broken line in Figure 2(c). However, if the first electrodes (4) cannot withstand the applied voltage Vs, an arc discharge is produced between the first electrodes (4), and current starts to flow all at once through the first electrodes (4) and the resistor (9). The voltage Vp drops drastically to zero from Vp2 as indicated by the solid line in Figure 2(c).

[0025]

The user calculates the impedance Zc1 of the first electrodes (4) from the applied voltage Vp1 and the current Vc1 through the first electrodes (4) using the equation below.

[0026]

$$Zc1 = (Vp1 - Vc1)/ic1 = (Vp1 - Vc1)\ Rc/Vc$$

Also, the halogen concentration in the gas is premeasured by ion chromatography, the impedance Zc1 within gas is obtained, and the plot as shown in Figure 3 is prepared. When the halogen gas

concentration is low as shown in Figure 3, the current Vc1 is large for the same applied voltage Vp1, and Vc1 becomes smaller as the concentration increases. More precisely, the impedance correspondingly increases as the gas concentration increases.

[0027]

Accordingly, Vp1 and Vc1 are measured while the laser is in operation, and the impedance Zc1 is calculated. It is then converted into the halogen concentration of the gas by using the impedance Zc1 and Figure 3. When a decrease in the halogen concentration is detected, HCl gas is supplemented to the laser chamber (1).

[0028]

In this way, the halogen gas concentration can be held constant and a stable oscillation can be obtained without lowering the laser output. Also, the gas deterioration detection device in this application example can measure the concentration of halogen gas while the laser is in operation. Also, the measured results can be immediately obtained at that site while conducting a measurement.

[0029]

Also, because the current that flows through the electrodes also changes accordingly even if there is variation in applied voltage, measurements with satisfactory accuracy can be obtained with reduced error.

[0030]

Also, in this structure, 2 pairs of electrodes are installed, and the halogen concentration can be easily measured by obtaining the pulse voltage in a simplified circuit using 1 of the pairs. Also, it has the structure in which the space of the first electrodes is preliminarily ionized by the discharge of the second electrodes; therefore, there is the effect of preventing the generation of an arc discharge at the first electrodes (4). The first electrodes (4) performed preliminary ionization in this application example, but the preliminary ionization by the first electrodes (4) is not required for the measurement of the halogen concentration. A micro-current flows without the preliminary ionization, and measuring becomes possible.

[0031]

Also, the gap between the electrodes is short, and the applied voltage is low. Therefore, noise resulting from the discharge that may affect the laser and other devices does not occur. Moreover, the gas deterioration detection device in this application example consists of a small detection chamber (2), a mercury lamp (10), and a simplified circuit, and a compact device can be attained.

[0032]

Furthermore, because the structural parts, such as the electrodes, are not damaged even when a discharge occurs and the circuit design conditions do not change, the detection device may

be used in any laser oscillator after first establishing the relationship between gas concentration and impedance. A mercury lamp was used as the application means for the space between the electrodes, but the effect and the interaction are the same with electron guns that generate electron beams, ultraviolet lasers, and xenon flashlamps.

[0033]

Also, the irradiation of light from the ultraviolet emission lamp occurs only once in Application Example 1 of the present invention. However, through continuous irradiation of ultraviolet light while setting the high-value resistor (5Rs), the capacitor (6Cs), and the high-value resistor (8Rp) to appropriate values, a continuous discharge with a particular time constant can be obtained, and continuous measurements and data can also be obtained.

[0034]

Next, an excimer laser in Application Example 2 of the present invention will be explained by using the figures. As shown in Figure 6, the excimer laser in this application example is equipped with a pair of main electrodes (41) within a laser chamber (51). A D.C. voltage is applied to the electrodes (41) from a power supply (7). A mirror (52) and a half-mirror (53) are provided outside the laser chamber (51), which make up the laser resonator. Also, quartz laser output windows (52a) and (55b) are provided at the laser chamber (51) coaxially with the mirror (52) and the half-mirror (53).

[0035]

A gas introduction opening (54) for introducing the gas is provided at one section of the laser chamber (51). An HCl gas chamber (57), Xe gas chamber (58), and an Ne gas chamber (59) are connected to the gas introduction opening (54). A gas flow rate adjusting device (56) adjusts the flow rate of the HCl gas.

[0036]

Also, the gas deterioration detection device (60), which was shown in Figure 1 in Application Example 1, is arranged at one section of the laser chamber (51). First electrodes (4) and second electrodes (3) are arranged within the laser chamber (51). A high-value resistor (8), a resistor (9), a capacitor (6), a high-value resistor (5), a switch (22), a power supply (7), an ultraviolet light source (10), a measuring device (24), and a measuring device (23) are arranged outside the laser chamber (51). Also, the ultraviolet light input window (21) is arranged at one section of the laser chamber (51). The detection chamber (2) in the gas deterioration detection device in Application Example 1 is eliminated. Since these components are the same as in Application Example 1, their detailed explanation will be omitted.

[0037]

The measuring device (24) and the measuring device (23) output the measured results to the impedance calculation means (62). Also, the impedance calculation means (62) calculates the

impedance and outputs it to the control device (63). The control device (63) is connected to a memory means (66) shown in Figure 3, which stores the impedance Zc1 and the halogens concentration that corresponds to said impedance Zc1. Also, the control means (63) is connected to the flow rate adjusting device (56) and control the flow rate of the HCl gas to the flow rate adjusting device (56).

[0038]

Also, the half-mirror (67) is arranged coaxially with the laser output window (55) and guides a portion of the laser light that is emitted to the detection means (64). The detection means (64) measures the intensity of the light and outputs the measured result to the control device (63). The display device (65) is connected to the control device (63).

[0039]

Also, the control device (63) is equipped with an input means (67) through which the user sets the following 3 numerical values from the outside. The 3 numerical values to be set are the target halogen concentration Ph within the laser chamber (51), the rate of change dPh/dt of the allowable halogen concentration, and the allowable lowest output value WL of the laser.

[0040]

Next, the operation of the excimer laser device in this application example will be explained.

[0041]

First, the halogen concentration Ph, the rate of change dPh/dt of the allowable halogen concentration, and the allowable lowest output value WL of the laser are set at the control means (67). Also, the Xe gas, Ne gas, and the HCl gas are introduced into the laser chamber (51) from each of the gas chambers (57), (58), and (59) so that the halogen concentration of Ph is obtained. Since a voltage is applied from the power supply (7) to the main electrodes (41) in this state, the laser oscillates. Then, when the switch (22) of the detection device (60) is turned on, a micro-current flows to the electrodes (4) as explained in Application Example 1, and the measuring device (23) and the measuring device (24) measure Vc and Vp. These measured results are output to the impedance calculation means (62). The impedance calculation means (62) calculates Zc1 according to the equation indicated in Application Example 1, and outputs it to the control means (63). During this time, the detection device (60) performs continuous detection, and outputs the impedance Zc1 to the control means (63) during a specified period.

[0042]

The control means (63) searches the memory means (66) based on Zc1 and obtains the halogen concentration P. Also, the control means (63) calculates the rate of change dP/dt of the halogen concentration, then compares the obtained halogen concentration P to the halogen concentration Ph which is set by the inputting means. When the halogen concentration P is less than Ph, in other words, when it is decreasing, the flow rate adjusting device (56)

will be instructed to introduce HCl gas. The flow rate adjusting device (56) fills the laser chamber (51) with HCl gas according to the instruction. The control means (63) controls the flow rate of the HCl gas via feedback until the halogen concentration P reaches Ph. The control means during this time instructs the flow rate adjusting device (56) with a flow rate so that the rate of change dP/dt of the halogen concentration does not exceed the allowable rate of change dPh/dt of the halogen concentration, which is preset.

[0043]

Also, the intensity w of the output light is output into the control means (63) from the detection means (64) at the same time. The control means (63) converts the intensity W of the entire actual output light from the intensity w, which was obtained from the detection means (64), and the reflection ratio of the half-mirror (67). Then, the control means (63), when the intensity W of the entire output light has become less than WL, which is pre-established, despite the control of the halogen concentration P to Ph, as described above, instructs the display means (65) to display the fact that the output window (55) is dirty as shown in Figure 6(b). The display means (65) has a display as shown in Figure 6(b), and the user is requested to replace the output window (55).

[0044]

In this manner, the excimer laser in this application example has a gas deterioration detection device built in, and

the flow rate of the HCl gas is controlled by using the detected results. In this way, an excimer laser which outputs laser light at a prescribed intensity can be offered. Also, the HCl gas is added when the rate of change of the halogen concentration is below a prescribed value. As a result, the discharge of the main electrodes (41) can be made stable, and stable laser light at a prescribed intensity can be output.

[0045]

Furthermore, the detection of the halogen concentration and the detection of the laser output occur simultaneously in the excimer laser of this application example. Therefore, said decrease in the laser output will be the result of a dirty output window (55). Accordingly, an excimer laser can be offered in which maintenance can be easily and reliably performed by notifying the user of said fact on the display device (65), instead of the user relying on his intuition.

[0046]

Also, the gas deterioration detection device in Application Example 3 of the present invention is shown in Figure 4. A high-value resistor (8) is connected in series with the second electrode G2 (3b), and a resistor (9) is connected in series with the first electrode G1 (4b). These 2 pairs of electrodes that are connected to the resistor are connected in parallel and make up a circuit. Also, an ultraviolet light source (10) irradiates ultraviolet light not only between the second electrodes but also between the first electrodes. The gap between the second

electrodes (3) is made shorter than that between the first electrodes (4) so that they discharge before the first electrodes (4). A sufficiently large high-value resistor (Rp) is connected in series with the second electrodes (3). Also, the second electrodes (3) and the first electrodes (4) are arranged in close proximity at a distance so that those on one side generate preliminary ionization by the discharge at the electrodes on the other side.

[0047]

The D.C. voltage of the power supply (7) charges the capacitor (6) through the high-value resistor (5) and at the same time is applied to the second electrodes Ga (3a) and (3b) and the first electrodes G1 (4a) and (4b). As the light from the ultraviolet light emission lamp (10) or laser light is irradiated between the second electrodes G2 (3a) and (3b) and between the first electrodes G1 (4a) and (4b), the second electrodes that have a smaller gap between the electrodes are first discharged by the interaction between the trigger and the preliminary ionization by the ultraviolet light. In this way, the gas between the first electrodes is preliminarily ionized. Because the high-value resistor (8) is connected to the second electrodes (3), the voltage Vp drops only slightly, and the voltage Vp is applied between the first electrodes. The current (Ic3) flows between the electrodes of the first electrodes (4), to which the voltage Vp is applied, through this preliminary ionization. The electron density n_e is derived from this current by equation 1.

[0048]

n_e = Ic3/($e \cdot v_d \cdot A$) = (Vc3/Rc)/($e \cdot v_d \cdot A$)···(equation 1)
In the equation, Ic3: current (A); e: fundamental charge on the electron: ($1.6021/10^{19}$)C [sic; 1.6021×10^{-19} C)]; Vd: electron drift velocity (cm/sec), and A: discharge volume (cm^3). V_d changes depending on the conversion intensity of the electric field E/P (E: electric field; P: gas pressure) and the type of gas. The electron density can be converted by each constant number.

[0049]

On the other hand, the relationship between the electron density and the halogen concentration is pre-established as shown in Figure 5. As can be observed in Figure 5, the halogen concentration is high when the electron density is low; and the halogen concentration is low when the electron density is high.

[0050]

Accordingly, Vc3 is measured by the measuring means (23) while the laser is in operation, and the electron density and the halogen concentration can be obtained by using equation 1 and Figure 5. HCl gas is added to the laser chamber (1) if the halogen concentration drops.

[0051]

In this way, the halogen concentration can be held constant, and a stable oscillation can be obtained without lowering the laser output. Also, not only can the halogen concentration gas be measured while the laser with the gas deterioration detection device of this application example is in operation, but the measured results can also be obtained immediately on the spot.

[0052]

Also, in this structure, the voltage pulse is obtained with a simplified circuit structure in which 2 pairs of electrodes are installed and only 1 of the pairs is used, and the halogen concentration can be easily measured. Also, because the gap between each of the electrodes is short and the applied voltage is low, noise through a discharge that affects the laser and other devices does not occur. Moreover, the gas deterioration detection device in this application example can be constructed with a small detection chamber (2) and a mercury lamp (10), and it can be made into a compact device.

[0053]

Furthermore, because structural components, such as electrodes, are not damaged even through a discharge, the circuit design conditions do not change, and the detection device can be used in any laser oscillator by first understanding the correspondence between the gas concentration and the electron density. A mercury lamp was used as the application means for the

space between the electrodes in this structure, but the effect as well as the interaction remain the same even when electron guns that generate electron beams, ultraviolet lasers, and xenon flash-lamps are used.

[0054]

Also, the irradiation of light from the ultraviolet lamp occurred only once in the application examples of the present invention, however, continuous measuring can be attained and data can be obtained through a continuous discharge under a prescribed constant when the ultraviolet light is continuously irradiated by choosing the proper values for the high-value resistor (5Rs), capacitor (6Cs), and the high-value resistor (8Rp).

[0055]

As described in Application Example 2, an excimer laser with the integrated detection device in Application Example 3 can also be constructed. In this case, the impedance calculation means (62) in Figure 6 is used as the electron density calculation means, and the relationship between electron density and halogen concentration in Figure 5 is stored in the memory means (66). Other structures can be attained in the same manner as in Application Example 2.

[0056]

Effect of the present invention

The present invention can offer a compact detection device, which can detect the halogen concentration within an excimer laser chamber in a short period of time, and an excimer laser device with said device.

Brief description of the figures

Figure 1 is an explanatory diagram which shows the structure of the gas deterioration detection device in Application Example 1 of the present invention.

Figure 2 is a graph which shows waveforms of the application voltages in the circuit in the device in Figure 1.

Figure 3 is a graph which shows the relationship between halogen gas concentration and impedance.

Figure 4 is an explanatory diagram which shows the structure of the gas deterioration detection device in Application Example 3 of the present invention.

Figure 5 is a graph which shows the relationship between halogen gas concentration and electron density.

Figure 6 is an explanatory diagram which shows the structure of the excimer laser device with the gas deterioration detection device attached in Application Example 1 of the present invention.

Explanation of the reference numbers

1, 51···laser chamber, 2···detection chamber, 3···second electrodes, 4···first electrodes, 5···high-value resistor, 6···capacitor, 7···power supply, 8···high-value resistor, 9···resistance, 10···ultraviolet light emission lamp, 11···ultraviolet light, 21···ultraviolet light input window, 22···switch, 23, 24···voltage measuring devices, 41···main electrodes, 52···mirror, 53···half-mirror, 54···gas introduction opening, 55···laser output window, 56···flow rate adjusting device, 57···HCl gas chamber, 58···Xe gas chamber, 59···Ne gas chamber, 60···gas deterioration detection device, 62···impedance calculation means, 63···control means, 64···detection means, 65···display device, 66···memory means, and 67···input means

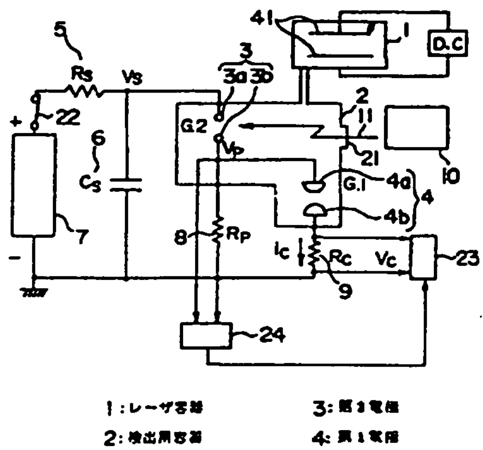


Figure 1

Application example of the present invention (Figure 1)

Key:
1 Laser chamber
2 Detecting chamber
3 Second electrodes
4 First electrodes

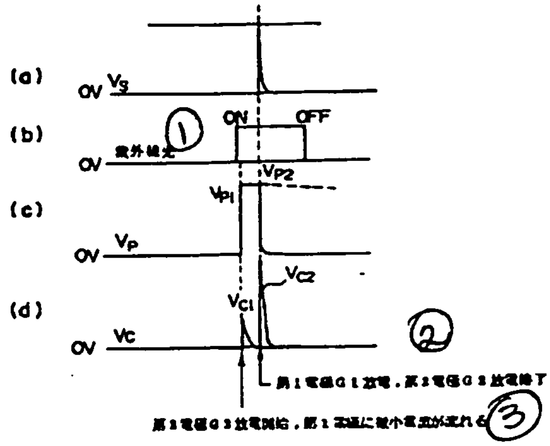


Figure 2 (a), (b), (c), and (d)

The applied voltage waveforms in the application example of the present invention (Figure 2)

Key:
1 Ultraviolet light
2 Completion of the discharge of the first electrodes (G1) and the discharge of the second electrodes (G2)
3 Start of the discharge of the second electrodes (G2), and a micro-current flows into the first electrodes

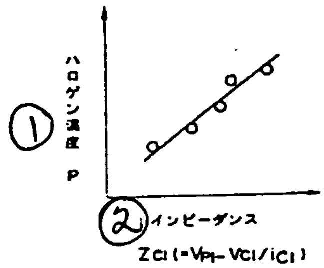


Figure 3

Correspondence between the concentration of the halogen gas and the impedance (Figure 3)

Key: 1 Halogen concentration
2 Impedance

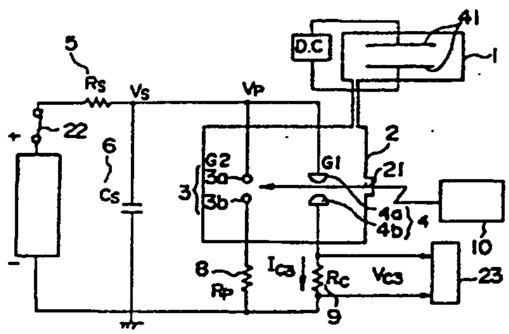


Figure 4

Another application example of the present invention (Figure 4)
Figures 6 (a)

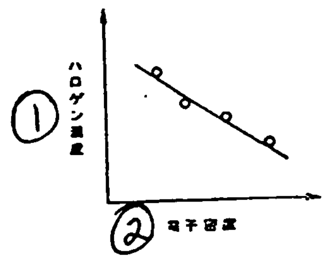
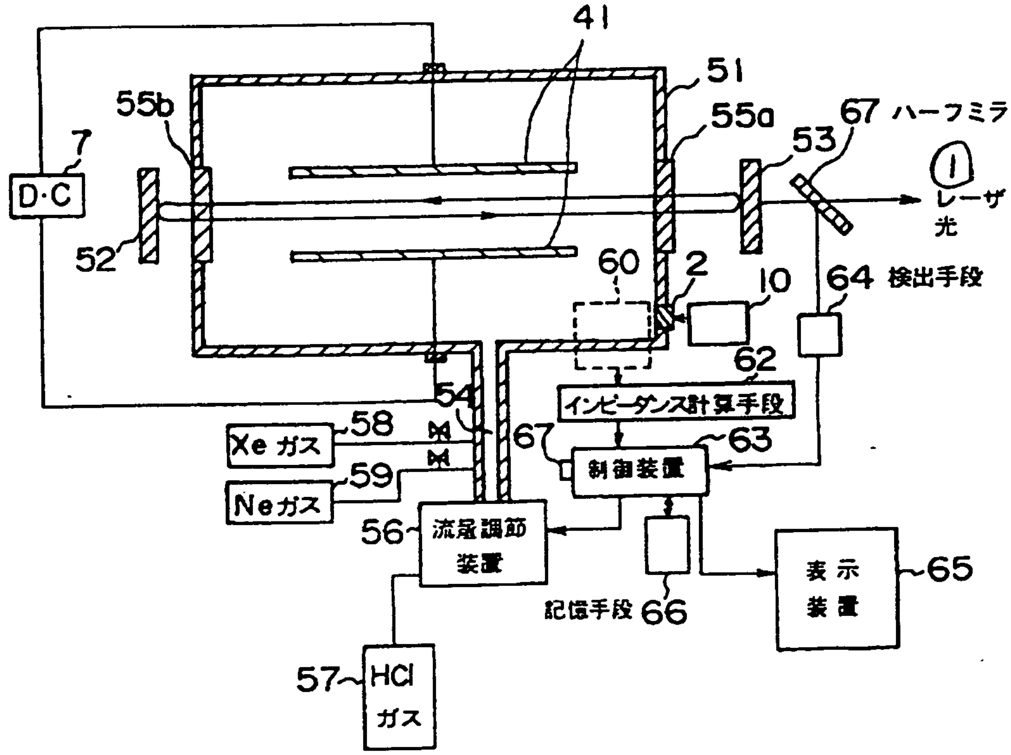


Figure 5

Diagram of the relationship between halogen gas concentration and the electron density (Figure 5)

Key: 1 Halogen concentration
2 Electron density

(a)



(b)

表示装置６５の表示内容

異常，出射窓が汚れています

Key: 1 Laser light
2 The contents of the display at the display device (65). Abnormal, the output window is dirty.
56 Flow rate adjustment device
57 HCl gas
58 Xe gas
59 Ne gas
62 Impedance calculation means
63 Control means
64 Detection means
65 Display device
66 Memory means
67 Half-mirror